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Research Article

Estimation of species diversity of trees and shrubs using ETM+ sensor data (Case study of forests in Qalajeh Kermanshah province)

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Abstract

The use of remote sensing techniques as a suitable solution to estimate the levels of species diversity is of high importance for the sustainable management of forests. In order to investigate the potential of using sensor data from Landsat 7 ETM+ to estimate species diversity in the Zagros forests, digital data related to the August 7, 2002 from forests in the Qalajeh Kermanshah Province were analyzed. To this end, 114 sample plots were created using a systematic method. The plots had the dimensions 60 × 60 m and were positioned using a GPS device. The number of features, species, DBH and crown diameter in two directions, North-South and West-East harvest, were recorded. The Shannon-Wiener species diversity index per sample plot was calculated. After testing for normalization using the Kolmogorov–Smironov test, the Shannon-Wiener index was used as the dependent variable, and spectral values from original and synthetic bands from different processing on the ETM + data were used as the independent variables. The Pearson correlation was used to select the best bands among 40 major and artificial bands, and three-bands (ETM4, NDVI and MSAVI2) were selected. To analyze the relationship between species diversity and these bands, the best subset regression was used. The results showed that the combination of linear regression, in which ETM4, NDVI and MSAVI2 were set as the independent variables, compared to other bands and compounds that were used for species, are better able to estimate the tree and shrub diversities ($Radj^2$=0.327). The results of this study indicate that ETM+ sensor data has a relatively low ability to estimate species diversity of trees and shrubs in the study area that was analyzed.

Keywords: ETM+, regression model, species diversity, Zagros, Qalajeh

Introduction

Species diversity is an important feature of biological communities, and different methods are used to measure it (Krebs, 1988). Diversity of organisms, ways to measure diversity and hypothesis testing of the causes of diversity are historically popular issues among ecologists (Barnes *et al*, 1998). Zagros forests are important and valuable natural resources in areas of Iran. They cover more than one-fifth of the area and about one-third of the total population of the country. The number of tree and shrub species is more than 190, and there are 2.5 million hectares of forests there (Fattahi, 2005). To regenerate the forest and enrich its ecology, the characteristics and habitat needs of the existing species must be known (Jazeerei and

Ebrahimi Rostaghi, 2003). Principled and proper forest management can lead to increased biological diversity (Halpern, 1995 and Larsen, 1995). The classification and grouping of the ecological habitat and forest from 1980 until today have been the main issues in forest management (Barnes *et al*, 1998). In terms of species biodiversity of ecosystems, the focus has been on species diversity of the most famous species (Daniels *et al*, 1995; Lust and Nachtergale, 1996). Remote sensing data are the data sources that measure diversity on local, continental and global scales (Rao, 1995; Walker, 1992). The protection of biodiversity for the future of forestry is an important task (Rezai and Soltani, 2003, Emborg, 1996). Using a good indicator plant can help reduce the effect of other phenomena, such as soil texture, rocks and water areas (Komela, 2008; Tucker,1979). In order to evaluate species diversity data from the Golestan National Park and demonstrated that remote sensing can be used with TM and related index values, and that the correlation between plant richness and diversity can be calculated based on data from the land that was studied (Negendra, 2001). The results showed that indicator vegetation NDVI is useful to evaluate the parameters of various biophysical characteristics (e.g. vegetation, biomass, leaf area index) (Smith, 1990; Turner *et al*, 2003). A studied the diversity and species richness in four units of a forest using an indicator plant, and the correlation between numerical values of the average pixel NDVI values that were derived from the richness of the Shannon index, which was based on data from the land were determined (Bawa *et al*, 2002). Results showed that there was a positive correlation between mean NDVI and tree species diversity in all of the pixels there. In the correlation between plant species richness and the NDVI in California was studied, and the correlation between them was verified (Walker et *al*, 1990). Using data from the ETM + sensor to study woody species diversity of tropical dry forests in south Florida in America. The results improved by a factor of 50.0 for the NDVI, indicating that it is a very important index to estimate the richness of the tree diversity using data from the satellite (Gillespie, 2005). Satellite data assessment to determine the diversity of tree heights in Chiapas, Mexico and concluded that satellite data can be an important source of information to protect the diversity of tree and shrub species for natural resource managers (Gillespie *et al*, 2008). Using the NDVI and the ETM + data sensor to determine species richness in tree forests of tropical Panama, and the results indicate that the amount of factor explaining improved by a factor of 58.0 (Gillespie *et al*, 2009). The main goals of this study are to understand the correlation between diversity values based on satellite sensor data ETM+ (bands spectral values) and the Shannon-Wiener diversity index that were obtained from ground data and to create a model for estimating species diversity of trees and shrubs in Zagros forests.

Material and Method

The study area, with an area of over 2110 hectares of the Qalajeh forest, is located in the Kermanshah province at longitude 46° 18′ 05" to 46° 22′ 18" and latitude 33° 58′ 42" to 34° 01′ 26" and ranges in altitude from 2000 to 1500 meters above sea level. According to the Dumarton climate classification is cold and semi-humid.

Satellite data

In this study, data from Landsat 7 ETM + sensor pass No. 167 and rows 36 to 29 from 7 July 2002 were used. Multi-spectral bands 7-1 were used for the equivalent of a resolution of 30 meters and 15 meters band Pancromatic.

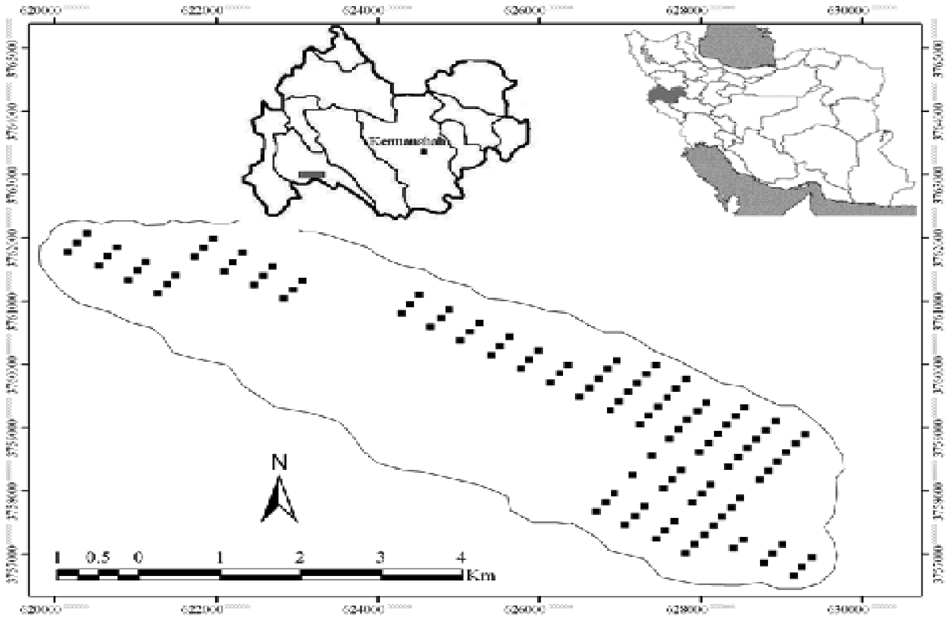

Figure 1: location of study area in Iran and Kermanshah

Processing satellite data

The ETM + data quality is determined by radiometric errors and pixels are repeated through Histogram were studied. In this study, the desired image used non-parametric polynomials and a final number of 55 ground control points, and the RMSE was equal to 0.39 for the X axis and 0.46 for the Y axis for the ground reference. Also, to reduce the atmospheric effects, the COST model was used. In order to improve vegetation detection for classification, artificial bands were created by performing multiple transforms on the different spectral bands, including the main mathematical operations on the bands, the main component analysis into tasseled cap, vegetation indices. Also to use of capabilities integrated and place panchromatic image integration and two semi-automatic method for converting color space used to compare data obtained in the classification process was conducted. A high correlation between the data in the spectral bands, such as information repeated between bands, was considered. Routine methods, including selecting bands and a divergence indicator, were used to determine the optimal indicator factor (OIF) based on the amount of standard deviation and the correlation coefficient between bands (Sellers, 1987). In this study, to select the best bands to use in the modeling, the Pearson correlation coefficient was used so that the total bands between the original and synthetic bands were selected such that the correlation coefficient between them was small (Mahiny and Turner, 2003).

Statistical analysis

The values of the Shannon-Wiener diversity index, the center position of plots and spectral values corresponding to each piece of extracted sample bands were recorded and analyzed in Minitab 13 software. Finally, a model was selected that contains the most coefficient representation (representation factor correction) and minimum mean square error using Cp (Mohammadi and Chitsaz, 2002).

Rated credibility regression models

To evaluate the fitted regression models and results of the statistical analysis, 15% of the data were randomly selected, evaluated and separated from the rest. Thus, using statistical regression, the number of trees per hectare site that had the criterion data was estimated. Then, having estimated values from both methods, real values were used in the following statistical criteria to compare the results of the regression model (equation 1 and 2) [18].

$$MSE = \frac{1}{N}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$ Equation (1)

$$RMSE = \sqrt{\sum_{i=1}^{n}\frac{(\hat{y}_i - y_i)^2}{N}}$$ Equation (2)

Where N is the number of samples, $\hat{y}_i$ is the estimated value and y_i is the actual value. Not all parts of the best estimate, estimate that a minimum mean square error and root minimum mean square error is square (Naimi, 1999).

Results and Discussion

The Kolmogorov-Smironov test showed that Shannon-Wiener diversity index values have a normal distribution (p-value<0.05) after logarithmic conversion of the values were (p-value>0.05), and a histogram of the Shannon-Wiener diversity index values also suggests they are normally distributed after conversion. In this study, bands ETM4, NDVI and MSAVI2 have the lowest correlations to other bands and were selected for the modeling study. A positive Pearson correlation level of 95% indicates that the increase in species diversity of trees and shrubs is associated with the increasing values in three selected spectral bands.

Review of regressions between the dependent and independent variables

The relationship between the Shannon-Wiener species diversity index (dependent variable) and spectral values (independent variable) was evaluated, and the best regression model was identified. The values of R^2, R^2_{adj}, MSE, Pearson and Cp were calculated for all regression models. The models vary in the number of acres that were calculated, and the results of regression analysis showed that the linear model with ETM4, NDVI and MSAVI2 as independent variables is better able to estimate the species of trees and shrubs in comparison with other variables that were used (Table 1).

Table 1: Results of the multiple regression analysis to estimate species diversity using the ETM + sensor data

Model Parameters: $Y=10^{(B0+B1X1+B2X2+…BnXn}$									
RMSE	MSE	R^2_{adj}	R^2	CV	B_3X_3	B_2X_2	B_1X_1	B_0	Shanon-Winer
0.5	0.257	0.327	0.33	1	-0.000525(MSAVI2)	0.000143(NDVI)	0.00132(ETM+)	1.75	

Mapping species diversity

On this map, using of ETM4, NDVI and MSAVI2 bands and lighter tone of green indicates low species diversity, and a darker tone of green indicates high species diversity (Fig. 2).

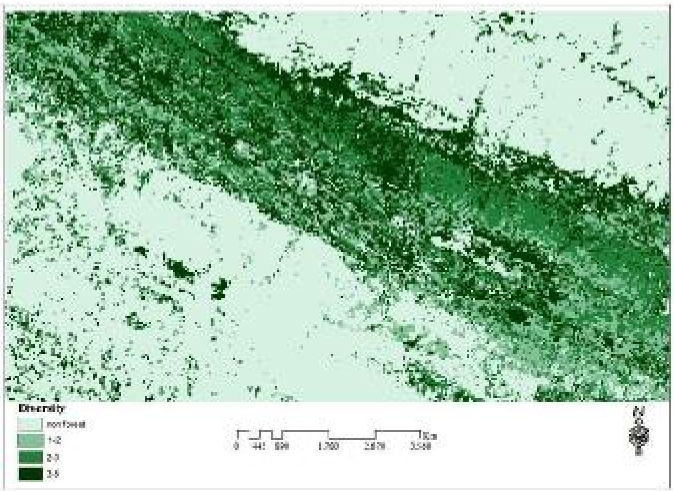

Figure 2: Map of species diversity using multivariate regression of ETM + data

Conclusion

Diversity is one of the important properties that determine the vegetation needed to field measurements, the limits of its own and must determine which tools and methods to use auxiliary data such as digital satellite is used. Atmospheric correction in a remote sensing study is necessary, particularly in cases where the actual amounts of energy from scintillated objects are required. In accordance with correcting atmospheric studies and remote sensing are required before using them in the process of classification and thematic information extraction (Naimi, 1999). The criteria that are used to evaluate the accuracy of the model can include the correction coefficient, the mean square error and plotting the residuals distribution chart (Richard and Xiuping, 1999). The results of regression analysis showed that the linear combination of bands ETM4, NDVI and MSAVI2 as independent variables, in comparison with other compounds used by bands, was better able to show species of trees and shrubs (Bawa, 2002). In this study, the infrared index was determined to be very important to estimate the species diversity of trees and shrubs, and this wavelength was used due to the high reflection in the infrared spectrum (Bawa, 2002; Willis and Whittaker, 2002). Correlation coefficients between species diversity and range of values in different bands corresponding positive and reflects the increasing range of different wavelengths, tree and shrub diversity also increased. The dense masses, in which there is more species diversity, reflect a large amount of the infrared spectral range, but in sparse masses, where the species diversity is low, reflected infrared is decreased because the red wavelength enters into the forest and spreads, which influences its absorption and ultimately reduces its reflection. Thus, increasing the diversity and density of the canopy tree and shrub species increases the rate of reflection in this range. The ability to obtain specific conditions, such as status of forests in the Zagros topography, rocky areas, open canopy forest and soil, is extraordinary. The remaining factors are normal, including the stability of variance, corrected coefficient representation (R^2_{adj}= 0.327) squares and mean square error (RMSE = 0.5). Many reasons explain the low rate correction factor in this research when to compared (R^2 = 0.50) (Gillespie, 2005). By using of R^2 = 0.58 can be less than the density of forest cover and reflects the high non-forest. However, the low density of trees and the open canopy in some areas, and consequently severe spectral interference field from soil cover, caused the coefficient value for correct representation for this region to be significantly reduced (Gillespie *et al*, 2009)). According to the survey results, the estimation of species diversity of trees and shrubs using data from the sensor ETM + had satisfactory results, and this type of data can be used to make estimates for species diversity in similar areas. The use of data with higher resolution and location using the new modeling method for quantitative estimation of forest characteristics is suggested.

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